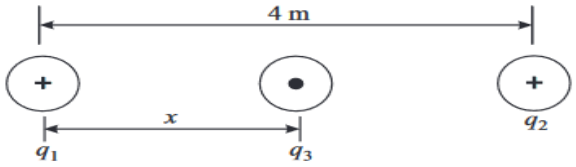
Tutorials series for the electrokinetics chapter

Exercise N° 1

A charge $+q_1$ = 12C is placed at a distance of 4.0 m from another charge $+q_2$ = 6C, as shown in the figure below. Where should a negative charge $q_3$be placed on the line joining q_1 and q_2 so that the charge q_3 does not experience any force?

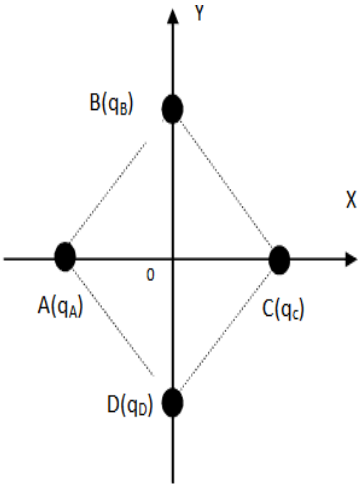
Calculate the distance where the charge should be placed



Three charges placed in straight line

Exercise N°2

Consider an orthonormal plane reference (x,o,y) (see figure). At point A we place a charge q_A=-q, at point B a charge q_B=+2q, at C a charge q_C=+3q, and at D a charge q_D=-2q. Assume $OA = OB = OC = OD = a = 5cm$ and q=10-9 C.



1- Determine the total potential V_O at point O and calculate its value.
2- Determine the total electric field vector $\overrightarrow{E_O}$ at point O and calculate its modulus.
3- Place a charge q'=q/2 at point O. What is the value of the resultant of the forces exerted on charge q'. Assume K=9.109 SI.
4- Determine the total electric field vector $\overrightarrow{E_D}$ at point D.

Exercise N°3

1- A capacitor with a capacity of 100µF must have an energy reserve of 50 Joules in order to operate a flash lamp.
a. What voltage is required to charge the capacitor?
b. What is the charge passing through the flash lamp?
2- A parallel-plate capacitor is made up of 5 cm square plates separated by a distance of $0.1\ mm$. Find its capacitance:
a. In air ($\varepsilon = \varepsilon_0$).
b. In a medium of $\varepsilon = 6\varepsilon_0$

Exercise N°4

Consider the circuit diagram below.

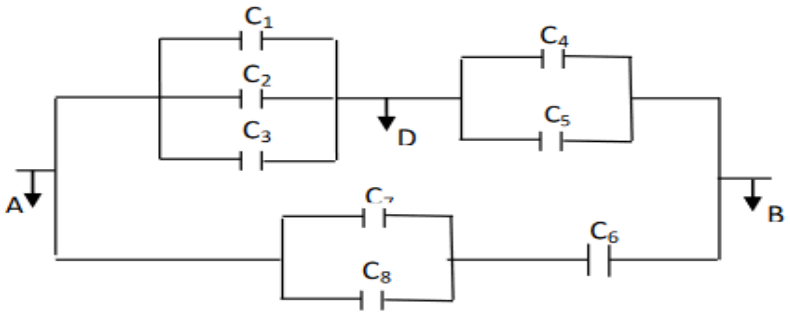
1- Knowing that capacitor C_1 carries charge Q_1=10 µC, what will be the potential difference VAD between points A and D?

2- Determine the charges Q_2 and Q_3 of capacitors C_2 and C_3 respectively.

3- Given the potential difference between B and D equal to 2V, calculate the charges Q_4 and Q_5 of capacitors C_4 and C_5.

4- What is the equivalent capacity Ceq of the entire circuit?

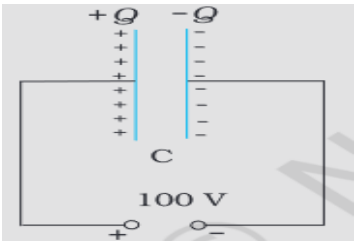
We give : C_1=4µF, C_2=3.5µF, C_3=2.5µF, C_4= C_5= C_7= C_8=5µF, C_6=10µF



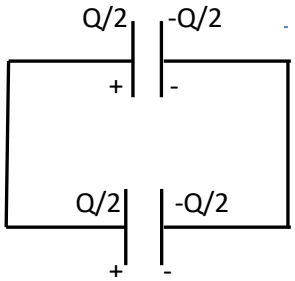
Exercise N°5

1- In figure (a) A 900 pF capacitor is charged by 100V battery. How much electrostatic energy is stored by the capacitor?

2- The capacitor is disconnected from the battery and connected to another 900 pF capacitor [Fig. 2.31(b)]. What is the electrostatic energy stored by the system?



(a)

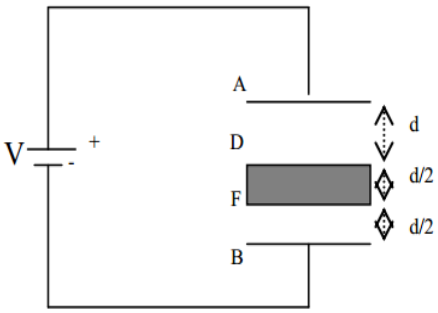


(b)

Exercise N°6

We consider a parallel-plate capacitor, formed by two rectangular plates A and B of length L and width X. The two plates are separated by a distance of 2d.

1. Calculate the charge accumulated by the capacitor when a voltage V is applied between the plates.
2. A metal plate of thickness d/2, initially neutral, is introduced between plates A and B (with the same dimensions). Represent qualitatively the new charge distribution on plates A, B, D, and E.
3. Calculate these charges.



Given: L = 12 cm, X = 10 cm, d = 2 cm, V = 400 V

Exercise N°7 : Charge of battery

To recharge a battery, a charger delivers a current of 5.0 A at 12 V and operates for 10 hours.

1. What amount of charge flows through the power supply wires of the battery during this charge?
2. Charge carriers are electrons. How many electrons flowed during this charge?

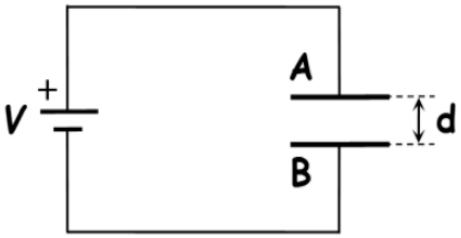
Exercise N°8

We consider a parallel-plate capacitor, formed by two rectangular plates A and B with an area of $S = 100cm^2$ and separated by a distance of $d = 1\ cm$.

1. Calculate the capacitance of the capacitor.
2. A voltage $V = 200\ V$ is applied between these plates.

a) Calculate the accumulated charge by the capacitor.

b) Calculate the stored energy in the capacitor.



3. The capacitor is disconnected, and one of the plates is moved an additional$0.5\ cm$.

a) Calculate the new energy stored in the capacitor.

b) Calculate the potential difference across the terminals of the capacitor.

Given: $\boldsymbol{\varepsilon_0 = 8.85\ 10^{-12}\ F/m}$

Exercise N° 9

A metal wire is carrying an electric current, which is known to consist of electrons, such that the charge passing through any cross-section is given by the expression: $q(t) = -0.5t$, where $q(t)$ is expressed in coulombs.

1- What is the value of the current intensity $i(t)$?

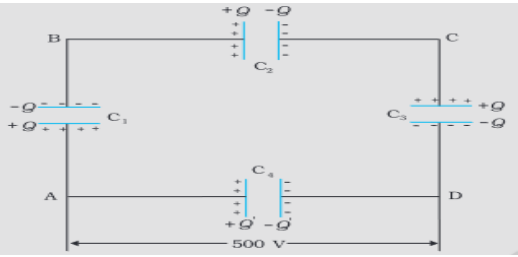
3- What is the number of electrons that flow through a section of the wire each second?

Exercise N°10

A network of four 10 mF capacitors is connected to a 500 V supply, as shown in Figure. Determine:

1- The equivalent capacitance of the network

2- The charge on each capacitor. (Note, the charge on a capacitor is the charge on the plate with higher potential, equal and opposite to the charge on the plate with lower potential.)

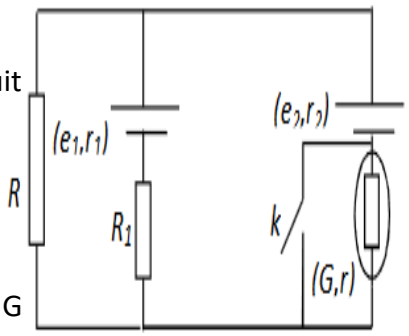


Exercise N° 11

The following electrical circuit consists of two batteries (e_1, r_1) and (e_2, r_2), a galvanometer (G,r), two resistors R_1, and R and a switch k.

k is closed:

1. Give the numbers of junction N, branches B and independent loop M.
2. Applying Kirchhoff's laws, calculate the currents flowing in each circuit branch.
3. Calculate the power supplied, consumed and lost in the circuit.
4. Deduce the Power efficiency



k is now open:

5. For what new value of electromotive force (e.m.f) e_2 does the G galvanometer display a current of zero current?

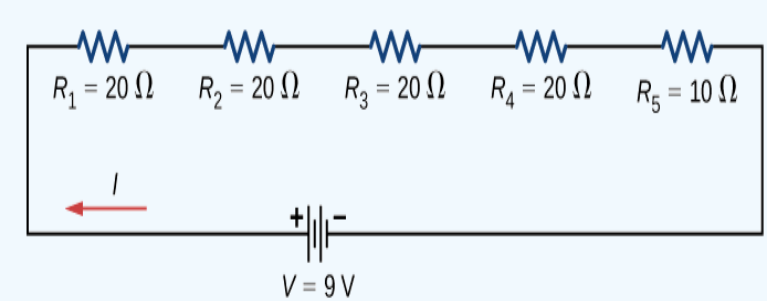
Given : R_1 =100Ω, R =200Ω, *e_1(12V, 2Ω), e_2(9V, 1Ω).*

Exercise N°12 : **Equivalent Resistance, Current, and Power in a Series Circuit**

A battery with a terminal voltage of 9 V is connected to a circuit consisting of four 20Ωand one 10Ω resistors all in series (Figure). Assume the battery has negligible internal resistance

a. Calculate the equivalent resistance of the circuit.
b. Calculate the current through each resistor.

c. Calculate the potential drop across each resistor.
d. Determine the total power dissipated by the resistors and the power supplied by the battery.



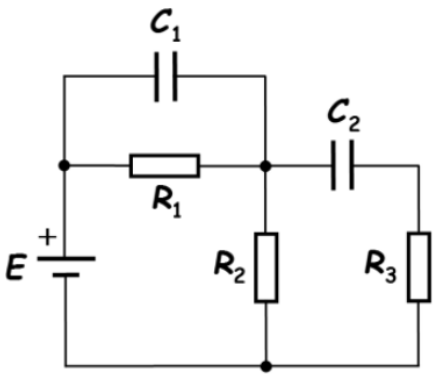
Exercise 13: Analysis of a parallel circuit

Three resistors R_1=1.00Ω, R_2=2.00Ω, and R_3=2.00Ω, are connected in parallel. The parallel connection is attached to a V=3.00V voltage source.

a. What is the equivalent resistance?
b. Find the current supplied by the source to the parallel circuit.
c. Calculate the currents in each resistor and show that these add together to equal the current output of the source.
d. Calculate the power dissipated by each resistor.
e. Find the power output of the source and show that it equals the total power dissipated by the resistors.

Exercise N° 14:

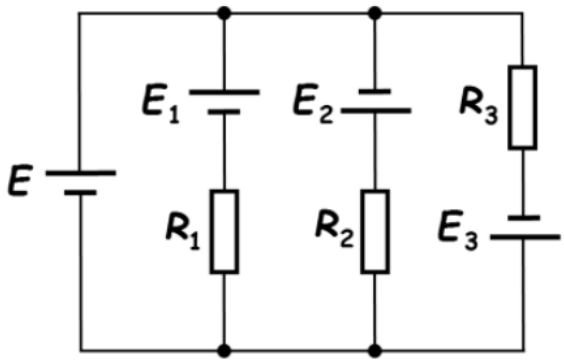
Consider the electrical circuit in the following figure, where the capacitors are initially completely discharged. We are given:
$E = 10\,V;\ R_1 = 1k\Omega;\ ;\ R_2 = 2k\Omega;\ \ R_3 = 2.2\ k\Omega;\ C_1 = 2.2\ \mu F;$
$C_2 = 3.3\ \mu F$



1. Calculate the voltage across each of the capacitors, if each of them is charged to its final voltage. Calculate the charge carried by each capacitor.
2. Calculate the currents I_1, I_2, and I_3 in resistances R_1, R_2, and R_3.
3. Calculate the energy stored by the system.

Exercise N°15:

Consider the circuit in the following figure with:
$E = 10\,V; E_1 = 5\,V;\ \ E_2 = 3\,V\ \ E_3 = 6\,V\ , R_1 = 1k\Omega;$
$R_2 = 2.2k\Omega;\ R_3 = 3.3\ k\Omega;$



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1. Calculate the current intensity in each branch of the circuit.
2. Calculate the total power dissipated in the circuit.